Recommendation For Incorporating Laboratory Specific Sustainability Measures into EO13514 Implementation

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U.S. Department of Energy
Energy Efficiency and Renewable Energy

INDEX

1 Introduction

1.1 Background

On October 5, 2009, President Obama signed Executive Order (EO) 13514 to establish an integrated strategy towards sustainability in the Federal government and to make reduction of greenhouse gas (GHG) emissions a priority for Federal agencies.
Section 8 of the EO13414 requires each agency to “develop, implement, and annually update an integrated Strategic Sustainability Performance Plan that will prioritize agency actions based on lifecycle return on investment.” The President’s Council on Environmental Quality (CEQ) and the Office of Management and Budget (OMB) has jointly developed guidance and template for the agency sustainability. The template establishes goals for High Performance Sustainable sites (Section 4) and Water Use Efficiency and Management (Section 6).

Guiding Principles are identified by the OMB’s Memorandum of Understanding published in early 2006. They are:
Employ Integrated Design Principles
Optimize Energy Performance
Protect and Conserve Water
Enhance Indoor Environmental Quality
Reduce Environmental Impact of Materials

In addition The Energy Independence and Security Act of 2007 (EISA 2007) established energy management goals and requirements while also amending portions of the National Energy Conservation Policy Act (NECPA). It was signed into law on December 19, 2007.

It should be noted that the projects shall meet the energy efficiency requirements for the new federal buildings, specifically to comply with Executive Order (EO) 13423 and EPACT 2005. The new construction energy efficiency requirements in EPACT 2005 /10 CFR 433 are less stringent than the requirements for EO13423. Therefore new buildings that meet the savings requirements of EO13423 will automatically be in compliance with the savings requirements in EPACT 2005/ 10 CFR 433.

1.2 Purpose of this document

The purpose of this document is to provide recommendation for incorporating laboratory sustainability measures in specific agency Sustainability Performance Plans. The energy use reduction directly correlates with the greenhouse gas emission. Although the amount of greenhouse gas emission depends on the source of energy (i.e. coal, natural gas, hydro etc) any reduction in energy use will reduce the greenhouse gas emission by some measure. The sustainability plan draws on resources developed by DOE and EPA for the 21st Century (Labs21) Program, energy consumption reduction best practices as well as other sources where appropriate. The recommendation in this document should assist the agency sustainability plans, following the CEQ-OMB template.

The document also lists additional resources for technical information on these strategies.

1.3 Impact summary

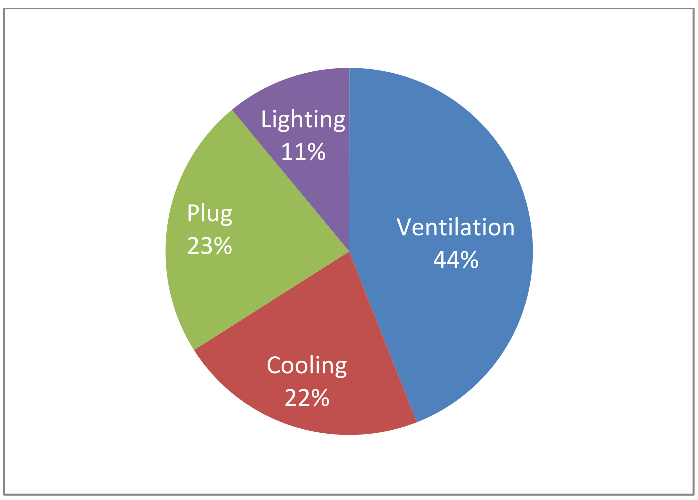
Laboratories usually consume much more power and require much more ventilation than a typical office building therefore there are ample opportunities for energy savings. This document addresses many of energy efficiency strategies along with their energy savings.

2 High Performance Sustainable Sites, Green Buildings (Section 4)

Template Section 4, paragraph e requires an agency to "Demonstrate use of cost-effective, innovative building strategies to minimize energy, water and materials consumption" and Para f requires that "Manage existing building systems to reduce energy, water and materials consumption in a manner that achieves a net reduction in agency deferred maintenance costs". This section will identify strategies for reducing laboratory building energy use.

2.1 Labs Energy Use Reduction Strategies for existing buildings operation:

Prevailing building codes and design standards provide a context in which best-practice strategies can be implemented. Consider the ventilation guideline provided by OSHA 29 CFR Part 1910.1450, which calls for a range of 4 to 12 ACH for a "laboratory" that often has an occupancy classification of "B". In contrast, the International Building Code (IBC) (2004) calls for a rate of 1 CFM/ft^2 for an occupancy classification of H-5, which is considered to be a hazardous environment. The energy use distribution in a typical laboratory is shown in the following figure:



This will result in following baseline figures that will be used throughout this guide:

Ventilation = 43 kW/year-sf
Plug Load = 23 kW/ year-sf
Cooling = 23 kW/ year-sf
Lighting = 11 kW/ year-sf
Total = 100 kW/ year-sf

In addition, it is assumed that the requirement for ventilation is at least 1cfm/sf. Also the full occupied working hours plus weighted unoccupied hours is equal to 5830 hours in a year.

2.1.1 Reduce Ventilation requirements

Ventilation guidelines should only be applied as their authors intended—as ranges, and not as absolutes. Standard practice often entails the blanket adoption of ventilation guidelines as constant values, with the ventilation rate rarely being dynamically controlled or otherwise tailored to the occupancy or conditions of the site, or optimized for energy efficiency or safety. Facility owners bear the consequences of requiring an unsubstantiated high ventilation rate, inadvertently forcing the engineer to design potentially wasteful heating, ventilation, air- conditioning (HVAC) system.

2.1.1.1 Strategies to Optimize Lab Ventilation

Codes and standards should be consulted before any modifications to the systems. These are explained in section 2.2.1 of this guideline.

Occupancy Control — Occupied versus Unoccupied Ventilation Rates
The differences in ventilation requirements between occupied and unoccupied modes should be considered. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Laboratory Design Guide suggests that setback control strategies can be used in laboratories to reduce air changes rates during unoccupied periods, e.g., at night and on weekends. The National Fire Protection Agency (NFPA) 45 Standard recommends a minimum ventilation rate of 4 ACH for unoccupied laboratories; some labs are designing for even lower rates.

High performance hoods Systems
Certain strategies will reduce ventilation in existing labs. By removing the unused hoods and capping the duct connection the leak through openings is eliminated. If the function of the hoods allows, replace large hoods with smaller which will result in lower ventilation demand. Many labs require an annual performance test to keep their hoods certified. This is a good opportunity to check if the sash opening can be restricted to reduce ventilation. Installation of a variable frequency drive (VFD) on exhaust fans and control of fan speed (ventilation) based on main duct static pressure or exhaust stack velocity is another strategy for reducing energy use. If the air change requirement (ACR) drives a higher flow rate than the fume hood exhaust requirement for a particular room, the ventilation rate will not be reduced.

Impact Summary:

Most of the labs are over ventilated from by 30% to 100% over minimum 1cfm/sf requirement. Assuming 1.1 W/cfm of fan energy and 30 btu/hr-cfm of air conditioning, the saving of .5 cfm/sf (average) is about 1 W/sf or annual saving of 5.8 kWh/year-sf or 5.8% of total energy use.

Strategies Summary:

- General
    - Optimizing ventilation rates
    - Install control to setback when lab is unoccupied
- Strategies Summary:
    - Remove unused hoods
    - Utilize High performance hoods Systems
    - Replace large hoods with smaller

- Restrict the sash opening
- Modify to use Two “speeds” exhaust fans for occupied and un-occupied
- Install VFDs on exhaust fans while monitoring exhaust stack velocity

Note: Refer to: http://www.labs21century.gov/pdf/bp_opt_vent_508.pdf

2.1.2 Optimizing HVAC systems

Chillers are typically more efficient with higher chilled water supply temperatures. Efficiency can increase by 1 to 1.5% for every degree F increase in chilled water supply temperature. Reduction of condenser water temperature also increases the efficiency of chillers. The overall system efficiency should be calculated and carefully considered since reducing condenser water temperature will increase energy use in cooling tower fans. Running cooling tower fans with VFDs and staging towers in parallel will reduce energy use drastically while system is not fully loaded. Running air handler fans with VFD has a similar impact. Based on fan laws, the power use has a fan speed to power 3. This means reducing fan flow by half, fan speed will be reduced by half and power use is reduced to about 1/8 (Head pressure will increase so the power demand will be higher than 1/8, refer to fan curve to calculate the exact number). Significant pump energy savings can also be realized by removing or opening pump throttling devices and installing a VFD to balance the flow.

Impact Summary:

Using VFD in exhaust fans and air handlers can reduce the power from 1.1 Watt/cfm to 0.9 Watt/cfm. This is 20% reduction if fan energy use or 8.8% in total energy saving.

An increase of 5^{o}F in chilled water supply temperature can save energy as much as 0.05 KW/ton of cooling. Just for ventilation amount and not considering envelope and people load, this can save 2 Btu/sf or o.2% of total energy use.

Strategies Summary:

- Raise chilled water supply temperature
- Reduce condenser water supply temperature
- Install VFDs on cooling tower fans, pumps, exhaust fans, and air handler fans.

2.1.3 Benchmarking and Evaluation of Improvements:

An effective strategy for saving energy is measurement of different metrics and compares those with the available benchmarks. Users can benchmark their facility using any of the metrics shown in Table 1, subject to data availability. Since some of the table content addresses the new building or building with major retrofit, some of these benchmark goals may not be achievable because of limitations in existing systems.

Table 1- Laboratory Performance Metrics & Benchmarks

ID	Name	Unit	Standard Practice	Good Practice	Better Practice
Building					
B1	Building Site Energy Use Intensity	Site BTU/gsf-yr	Meet ASHRAE 90.1; 3rd quartile in Labs21 database	20% below 90.1; 2nd quartile in Labs21 database	30% below 90.1; 1st quartile in Labs21 database
Ventilation System					
V1	Min Laboratory Ventilation Rate: Area-based	cfm/nsf			1 (justified if >1)
V2	Min Laboratory Ventilation Rate: Volume-based	ACH	> 6 (occ & unocc)	> 6 (occ); <= 6 (unocc)	6 (occ), 4 (unocc)
V4	Overall Airflow Efficiency (sup&exh W/ sup&exh cfm)	W/cfm	0.9	0.6	0.3
V5	Total System Pressure Drop	in. w.g.	9.7	6.2	3.2
V6	Fumehood Sash Mgmt (avg cfm/min cfm)	-	> 2	2.0 - 1.5	< 1.5
V7	Ventilation Energy Use Intensity	kWh/gsf-yr	3rd quartile in Labs21 database	2nd quartile in Labs21 database	1st quartile in Labs21 database
Cooling System					
C1	Lab Temperature Deadband	F	70-74		Justified if tighter than ASHRAE 55
C2	Lab Humidity Deadband	%	40-60		Justified if tighter than ASHRAE 55
C3	Cooling System Efficiency	kW/ton	> 1.0		<0.5
Heating System					
H1	Heating System Efficiency	No benchmark goals are available. Increasing boiler efficiency based on loading, replacing with new more efficient boiler, use of condensing boiler, and installing VFD on heating water pumps are some of the possible best practices.			
H2	Reheat Energy Use Factor	%	20%	5%	0%
Process Loads					
P1	Laboratory Design Plug-Load Intensity	W/nsf	10 - 25		Based on measured
P2	Laboratory Measured Peak Plug-Load Intensity	W/nsf	2-15		
P3	Laboratory Plug-Load Sizing Ratio (design/measured)	-	>4		Justified if >2
Lighting System					
L1	Laboratory Task Illuminance Design Setpoint	fc	80-100 (task+ambient)	Justified if >75	Justified if >50
L2	Laboratory Ambient Illuminance Design Setpoint	fc	80-100 (task+ambient)		Justified if >30
L3	Laboratory Lighting Installed Power Intensity	W/nsf	> 1.4	1.3	1.0

Impact Summary:

The impact will be in implementation of energy efficiency measure explored by benchmarking and monitoring.

Strategies Summary:

- Compare your facility with other facilities for opportunities
- Continuously Monitor and evaluate of the lab Energy Use

Note: Refer to: http://www.labs21century.gov/pdf/bp_metrics_508.pdf

Note: This strategy by itself does not have any impact. The impact comes from best practices as outcomes of information analysis resulted from this strategy

2.1.4 Minimize reheat

Conventional zone temperature control relies on reheat of cooling supply air in several zones. This is a wasted energy and it can be reduced or eliminated by varying the room temperature set points, utilizing the wasted heat from other zones/processes, and/or control air volume through CO/CO2 monitoring in lieu of constant set point. Provide zone based recirculating cooling in spaces with the highest cooling demands. Then, raise the central air handler cooling supply air temperature setpoint.

Impact Summary:

Reheat can be considered for 50% of total air as an average. Reheat load then is 7.5 Btu/sf. Elimination of reheat can save about 1% of total energy used.

Strategies Summary:

- Use wasted heat from other zones
- Control minimum OA based using CO/CO2 monitoring.
- Adjust room temperature setpoint.
- Use wider range for room temperatures while following ASHRAE recommendations.
- Install fan coil units or other recirculating air zone cooling equipment for zones with the highest cooling demands.

2.1.5 Lighting Systems

Although it is difficult to modify an existing building to provide more day lighting, evaluation is strongly recommended. Older labs usually have inefficient lighting system. Replacing the current lights with high efficiency ones such as LED type will reduce overall energy use. Occupancy sensors and timers are other tools that can reduce energy use. Localized (task) lighting is another strategy that may help reduce overall building energy use.

Impact Summary:

Reduction from 1.5 Watts/sf to 0.75 Watts/sf is possible. This will save 5.5% of the total energy used.

Strategies Summary:

- Employ day lighting as much as possible.
- Replace light with high-efficiency electrical lighting systems

- Install occupancy controls

Note: Refer to: http://www.labs21century.gov/pdf/bp_lighting_508.pdf

2.2 Labs Energy Use Reduction Strategies for new buildings and major retrofits

2.2.1 Reduce Ventilation requirements

Ventilation guidelines should only be applied as their authors intended—as ranges, and not as absolutes. Standard practice often entails the blanket adoption of ventilation guidelines as constant values, with the ventilation rate rarely being dynamically controlled or otherwise tailored to the occupancy or conditions of the site, or optimized for energy efficiency or safety. Some publications simply recommend 4 to 12 air changes per hour. The result can be excessive (or inadequate) ventilation for the lab in question, causing unnecessary energy expenditures. . Facility owners also bear the consequences of requiring an unsubstantiated high ventilation rate, inadvertently forcing the engineer to design a potentially wasteful HVAC system.

2.2.1.1 Strategies to Optimize Lab Ventilation

There are many design factors to consider when optimizing lab ventilation. These include the lab's layout (e.g., arrangement of equipment) and use (potential pollutants), control and removal of hazardous pollutants, and how to achieve adequate ventilation while attending to cooling load requirements.

The practices outlined below begin with codes or standards as a starting point for designs, while facilitating the adoption of ventilation specifications that ensure safety and energy efficiency. They emphasize lab-specific operations and control strategies as well as improvement in the ventilation design process with advanced computer or physical modeling techniques. These new techniques evaluate scenarios in which the system will need to respond to critical conditions (e.g., hazardous material spills, pollutant mixing factors), thereby reducing the guesswork typified by standard practice, to ensure that the facility will perform well during emergencies. Table 2 describes the common laboratory ventilation rates codes and Table 3 describes the common laboratory ventilation rates standards.

Table 2. Common Laboratory Ventilation Rate Codes

Code	Ventilation Rate	Comment
IBC -2004	1 CFM/ft2 for H-5	Section 415.9.2.6
IMC - 2004	1 CFM/ft2	Rate required for storage areas that exceed maximum allowable quantities of hazardous materials.

Table 3. Common Laboratory Ventilation Rate Standards

Standard	ACH Number	Comment
ANSI/AIHA Z9.5	The specific room ventilation rate shall be established or agreed upon by the owner or his/her designee.	The latest version of the American National Standards Institute and the American Industrial Hygiene Association standard (ANSI/AIHA Z9.5-2003, Section 2.1.2) states that a method based on "air changes per hour is not the appropriate concept for designing containment control systems. Contaminants should be controlled at the source." ANSI/AIHA also states that the air changes per hour do not "reflect actual mixing factors" of a particular room.
NFPA-45-2004	Minimum 4 ACH unoccupied; occupied "typically greater than 8 ACH."	According to the National Fire Protection Association's Standard NFPA 45, Appendix A: A 8-3.5 (NFPA 45 2004), room air cur rents in the vicinity of fume hoods should be as low as possible, ideally less than 30% of the face velocity of the fume hood. Air supply diffusion devices should be as far away as possible from fume hoods and have low exit velocities.
ACGIH–Ind. Vent.– 24th Ed.– 2001	The required ventilation depends on the generation rate and toxicity of the contaminant, not on the size of the room in which it occurs.	This standard from the American Conference of Governmental Industrial Hygienists states that "'Air changes per hour' or 'air changes per minute' is a poor basis for ventilation criteria where environmental control of hazards, heat, and/or odors is required." The impact of the laboratory's ceiling height is identified as one reason why an air change approach does not adequately address the required contamination control (Section 7.5.1, Air Changes).
ASHRAE Lab Guide–2001	4-12	The ASHRAE Laboratory Design Guide includes suggestions relating to the following: • Minimum supply air changes • Minimum exhaust air changes • Minimum outdoor air changes • Recirculation considerations
OSHA 29 CFR Part 1910.1450	4-12	The Occupational Safety and Health Administration specifies a room ventilation rate of 4 to 12 air changes per hour, which "is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control." This range is extremely broad and provides a designer with little guidance.

Occupancy Control — Occupied versus Unoccupied Ventilation Rates

The differences in ventilation requirements between occupied and unoccupied modes should be considered. The ASHRAE Laboratory Design Guide suggests that setback control strategies can be used in laboratories to reduce air change rates during unoccupied periods, e.g., at night and on weekends. The NFPA 45 Standard recommends a minimum ventilation rate of 4 ACH for unoccupied laboratories; some labs are designing for even lower rates.

Demand Control — Emergency Override Ventilation

Emergency override is a design refinement of the laboratory's supply and exhaust system to provide increased airflow and negative pressurization in an emergency. Such a design can reduce both energy use and first cost, unlike designs for continuous operation under rare worst-case conditions. Facility's automated control system can:

- Increase airflow through the lab during an emergency.
- Notify the facility's Environment, Health, and Safety (EH&S) staff.
- Discourage other workers from entering the laboratory.

Demand-controlled ventilation (DCV) is an emerging technology that utilizes pollutant sensors in order to provide real-time variable-air-volume ventilation control.

Control Banding for Optimizing Laboratory Ventilation Rates

Control banding is a means of classifying and grouping substances used in a process or activity by health risk for the purpose of determining an appropriate control strategy. Risk is most often described as a function of the likelihood and consequences of an event. For control banding, chemical classification has a similar risk basis. Toxicity (with consideration of the potential for skin absorption) is a measure of the consequence of exposure. The scale of use (quantity) and the ability to become airborne (volatility for liquids, or dispersibility for solids) are measures of the likelihood of exposure. Combinations of the different levels of toxicity, scale of use, and ability to become airborne under the conditions of use yield a score that equates to a control band.

Control banding can be applied to laboratory chemical operations. For a specific process and associated chemicals, the control band can specify what activities are permissible at a given room air change rate, require local ventilation, and must be conducted in a fume hood at a particular flow rate. (Substances with the highest risk are handled at hood flows set for optimum containment, or performed in a glove box.) A laboratory might optimize airflows for work up to a prescribed control band, or designate specific hoods, based on airflow and contaminant containment, for work within a certain control band.

Task Ventilation Control

Special-purpose laboratories provide an opportunity for designers to apply localized ventilation devices suited for a lab's particular use. Examples include animal labs using cage ventilation as a task-specific ventilation or local exhaust ventilation (LEV) strategy, electronic clean rooms using mini-environments, or biomedical labs using biological safety cabinets (BSCs).

Good practice therefore involves tailoring ventilation to a specific "task," and to a location within a laboratory equipped with LEV. When this is done, general ventilation rates may be relaxed without compromising safety or comfort at the location of the task. Note that LEV systems can increase energy use if improperly designed, installed, or operated due to high ventilation system pressure drop requirements, leaking devices, and "open" unused LEV devices.

Simulation Methods

Real or virtual laboratory models that permit airflow pattern simulations can optimize ventilation system layouts and laboratory designs. These performance-based approaches evaluate a simulated environment's hazards, e.g., they determine a chemical's clearing time by calculating the lab space's "mixing factors" for a given spill scenario rather than simply applying a universal, prescriptive air change rate. This is an iterative process that accounts for facility design features that influence one another. The following simulation methods may be applicable:

- CFD simulations
- Tracer gas simulations

- Neutrally buoyant bubble simulations

Impact Summary:

Even if the design is for 1cfm/sf requirement, it will save energy over designs that assume 8-12ACH of ventilation. Assuming 1.1 W/cfm of fan energy and 30 btu/hr-cfm of air conditioning, the saving of .5 cfm/sf (average) is about 1 W/sf or annual saving of 5.8 kWh/year-sf or 5.8% of total energy use. A potential saving of additional 5.8% is possible if demand control and LEV is utilized for ventilation.

Strategies Summary:

- Optimizing ventilation rates
    - Consider cfm/sf rather than ACH
    - Design for Cascading air from clean to dirty
    - Design for Setback when lab is unoccupied
    - Demand controlled ventilation based on monitoring of hazards and odors.
    - Control Banding (one rate doesn't fit all)
    - Apply simulation methods to optimize lab air change rates.

High performance hoods Systems and variable flow

Install high performance hood systems. Re evaluate design to reduce the number and size of the hoods. Multi-stack exhaust plenum with staged exhaust fans, VFD fans with controlled stack velocity. Certain strategies will reduce ventilation in existing labs. Design of a variable frequency drive (VFD) on exhaust fans and control of fan speed (ventilation) based on main duct static pressure or exhaust stack velocity is another strategy for reducing energy use.

Impact Summary:

High performance hoods and variable flow exhaust enable the lab operation to rely on demand control thus achieving energy savings similar to those noted in previous paragraph.

Strategies Summary:

- Fume hoods Systems
    - Design for minimum number and smaller size of hoods
    - Use variable air volume (VAV)
    - Consider high performance hoods
    - No Auxiliary Air hoods
- Multi-stack exhaust plenum with staged exhaust fans, VFD fans with controlled stack velocity

Note: Refer to: http://www.labs21century.gov/pdf/bp_opt_vent_508.pdf

2.2.2 Energy recovery (latent and sensible)

Due to ventilation requirements in the labs, the majority of conditioned outside air is exhausted. By using an enthalpy wheel or other types of air-to-air heat exchanger (e.g. duct to duct) the energy from exhausted air can be transferred to the supply air thus reducing overall energy use.

Impact Summary:

In mild climate, about 5,000 hours during cold seasons, heating of ventilation air is required. Heating load is about 20 btu/cfm. Heat recovery will save 3.4% over systems without heat recovery.

Strategies Summary:

- Install enthalpy wheels
- Install exhaust to outside air heat exchangers
- Run-around coils

2.2.3 Low-pressure drop design

The following table is an example of the impact of pressure drop on energy use. By reducing air handler air velocity from 500fpm to 300fpm, the air delivery efficiency is improved. The impact considering other strategies for improving air distribution system and exhaust fan can reduce energy use from 1.8 W/cfm to 0.6 W/cfm.

Component	Standard	Good	Better
Air handler face velocity-fpm	500	400	300
Total Static Pressure in. w.g.	9.7	6.2	3.2
Approximate W / CFM	1.8	1.2	0.6

Table 4 – Impact of face velocity on Pressure Loss in Air Systems

The components in air distribution system include the air handler (filters, coils, fans, dampers), ductwork, terminal boxes, sensors, dampers, zone coils, heat recovery devices, exhaust stack, and noise control devices.

Impact Summary:

As is shown in the table 4, saving of 1.2 Watts/cfm is possible. This is equal to about 7% saving in total energy used in the lab.

Strategies Summary:

- Reduce air velocity in the supply air delivery system by design.
- Select low pressure drop components in supply and exhaust air systems.
- Bypass air around components when not in use such as cooling coil

Note: Refer to: http://www.labs21century.gov/pdf/ bp_lowpressure_508.pdf

2.2.4 Right-sizing HVAC systems

An analysis of 26 laboratory projects by Martin [2004] showed that the over-sizing of cooling systems in these projects ranged from 40% to 300%, with an average of about 80%.

2.2.4.1 Best Practice Strategies

Measure equipment loads in a comparable lab.

Measurements can be made easily with commercially available data loggers. The usual configuration has the current transformers (CTs) and voltage connections inside the panel, and the actual logger outside the panel.

Use a probability-based approach to assess load diversity.

This approach uses a probability analysis to derive design loads based on the probability of simultaneous peak use of equipment. It is essentially a "bottom-up" approach to calculating diversity. While the depth and rigor of the analysis can vary, the approach essentially involves the following steps:

- For each type of heat source in a space, determine the number of sources and their peak outputs. This could be based on actual pieces of equipment, or the number and type of electrical and other outlets (as a proxy for equipment heat output). This information is often available from the programming documents.
- For each type of heat source in a space, determine the likelihood that it will be used. These data are typically obtained empirically through measurements or surveys.
- Use probability formulae or other statistical techniques to calculate the peak simultaneous load for the space, using the parameters described above for each heat source.

A major benefit of this bottom-up approach is that it provides a structured and logical way to calculate diversity factors for different levels of aggregation; i.e., as the number of pieces of equipment increases, a greater diversity can be assumed.

Compare design loads with most-likely maximum (MLM) loads.

Traditional design loads are chronically overestimated because designers assume that the worst-case equipment load will be simultaneous with the worst-case climate loads, while allowing large margins of safety and little consideration of diversity. One way to assess the potential for right-sizing is to compare the design loads to the "most likely maximum" (MLM) loads. This approach was developed and used in right-sizing the central plant at the new University of California, Merced campus [Brown 2002]. To avoid over-sizing the central plant for the new campus, the owner used measured benchmark data from other campuses to right-size the plant. Instead of just using design values that assume a worst-case estimate, a "most likely maximum" (MLM) load was also determined, based on the actual measured maximum loads in comparable buildings. Design for efficient operation at MLM load can be mandated, and the difference between the MLM and the design loads can be value-engineered to reach a reasonable margin of safety for each subsystem.

Configure equipment for high part-load efficiency.

Plant equipment, including fans, pumps, chillers, cooling towers and boilers, should be configured for high efficiency even at very low part-loads. Even if the equipment has been right-sized for the peak load, the load fluctuates widely, and the equipment operates at low part-loads many if not most hours of the year. Therefore, it is advisable to design the system for high efficiency at low loads. One solution is a modular plant design, where only the number of units needed is running. The design can accommodate increases in the load by adding modules. Plant designs with multiple modular primary components and optimized lead-lag logic programs will increase run-time hours at or near the peak efficiency of each primary component, thereby increasing the average plant efficiency, compared to plant designs with fewer and larger major system components. Another common strategy is to use variable-speed drives on equipment that frequently operates at part-loads.

Include energy efficiency in the procurement process.
By incorporating energy efficiency criteria into the laboratory equipment procurement process, owners can reduce equipment loads and obtain better estimates of actual equipment energy use. Furthermore, they—and especially high-volume purchasers—can create a market “pull” to develop more energy-efficient laboratory equipment. For example:

- Where available, specify EnergyStar™ equipment. Many of the refrigerators and computers used in laboratories are standard commercial products for which EnergyStar™ choices are available. EnergyStar™ also provides energy use information that can be used to estimate total loads.

- For equipment types that do not have a rating system such as EnergyStar™, request energy use information from manufacturers. At a minimum, this should include energy use for three operating modes: peak mode, typical (nominal) mode, and dormant (“sleep”) mode. This information can be used to compare the energy use of functionally equivalent options, as well as to estimate total loads.

Impact Summary:

As an average, better efficiency of equipment based on their original rating or being operated in their most efficient state, directly and almost one to one impacts energy savings in the lab.

Strategies Summary:

- Measure actual loads in similar labs
- Design for high part- load efficiency
- Modular design approaches for cooling and heating systems
- Include energy efficiency in the laboratory equipment procurement process.

Note: Refer to: http://www.labs21century.gov/pdf/bp_rightsizing_508.pdf

2.2.5 Systems that minimize or eliminate reheat

Conventional zone temperature control relies on reheat of cooling supply air in several zones. This is a wasted energy and it can be reduced or eliminated by varying the room temperature set points, utilizing the wasted heat from other zones/processes, and/or control air volume through CO/CO2 monitoring in lieu of constant set point. Provide zone based recirculating cooling in spaces with the highest cooling demands. Then, look to raise the central air handler cooling supply air temperature setpoint.

Impact Summary:

Reheat can be considered for 50% of total air as an average. Reheat load then is 7.5Btu/sf. Elimination of reheat can save about 1% of total energy used.

Strategies Summary:

- Dual-duct systems, multiple cooling loops at different temperatures
- Ventilation air with zone cooling coils
- Ventilation air with fan coils
- Ventilation air with radiant cooling

- Ventilation air with inductive cooling coils
- Chilled Beam

2.2.6 Benchmarking and setting goals for design:

An effective strategy for saving energy is measurement of different design metrics and to compare those with the available benchmarks. Users can benchmark their design using any of the metrics shown in Table 1, under Section 2.1.3.

Impact Summary:

Benchmarking by itself does not save energy. The energy efficiency measures explored by comparisons made and then implemented in the design will save energy. Plug load and ventilation are two most important areas of savings in this case. 10% better efficiency in process equipment can save 2.3% saving in total energy use. The impact of efficient ventilation such as demand control is even more and can save over 10% in total energy use.

Strategies Summary:

- Evaluate Plug Load
- Set the design goals and verify during commissioning
- Continuously Monitor the lab Energy Use

Note: Refer to: http://www.labs21century.gov/pdf/bp_metrics_508.pdf
Note: This strategy by itself does not have any impact. The impact comes from best practices as outcomes of information analysis resulted from this strategy

2.2.7 Lighting Systems
Design for day lighting is the most effective strategy. Other strategies such as occupancy control and use of efficient lighting systems are important as well.

Impact Summary:

Reduction from conventional 1.5 Watts/sf to 0.75 Watts/sf is possible. This will save 5.5% of the total energy used.

Strategies Summary:

- Day lighting and controls
- High-efficiency electrical lighting systems
- Occupancy controls

Note: Refer to: http://www.labs21century.gov/pdf/bp_lighting_508.pdf

2.3 Resources

Links to additional information
Guides: http://www.labs21century.gov/toolkit/bp_guide.htm
Guides: http://ateam.lbl.gov/Design-Guide/index.htm
Benchmarking: http://www.labs21century.gov/pdf/bp_metrics_508.pdf
Ventilation Optimization: http://www.labs21century.gov/pdf/bp_opt_vent_508.pdf
Lighting: http://www.labs21century.gov/pdf/bp_lighting_508.pdf

Right Sizing Lab Equipment Loads: http://www.labs21century.gov/pdf/bp_rightsizing_508.pdf
Low Pressure Design: http://www.labs21century.gov/pdf/bp_lowpressure_508.pdf

Standards and Programs
Labs21 EPC 2.2, Energy and Atmosphere, http://www.labs21century.gov/index.htm
LEED 2009, Energy and Atmosphere, http://www.usgbc.org/
ASHRAE 90.1, 2007 Appendix G, http://www.ashrae.org/publications/
ASHRAE Lab Guide 2001, http://www.ashrae.org/publications/page/1285

3 High-Performance Sustainable Design, Green Buildings- Water Use efficiency Management

Template Section 4, paragraph e requires an agency to "Demonstrate use of cost-effective, innovative building strategies to minimize energy, water and materials consumption" and Para f requires that "Manage existing building systems to reduce energy, water and materials consumption in a manner that achieves a net reduction in agency deferred maintenance costs". In addition, template Section 6, Paragraph c specifies to "Identify and implement water reuse (USAGE) strategies" This section identifies strategies for reducing lab water usage. The cost of deployment is low compared to impact, especially for new design.

Most laboratory buildings use significantly more water per square foot than standard commercial buildings do, primarily to meet their larger cooling and process loads. This greater need also provides laboratories with more opportunities to make cost-effective improvements in water efficiency, especially with respect to the amount of water they use in cooling towers and for special process equipment. A laboratory's water efficiency can also be improved by making a few changes in other types of equipment, such as water treatment and sterilizing systems. Alternative sources of water can often be effectively integrated into a laboratory's operations as another strategy for water use reduction.

3.1 Labs Water Use Reduction Strategies in existing operation:

3.1.1 Cooling tower make up water reduction

Cooling tower make up water use is an operational issue. By increasing cycles of recirculation (CR) (number of times the same water is returned to the tower), major savings in water use can be achieved. Water treatment alternatives such as chemical free water treatment should be considered to achieve the CR increase.

Impact Summary:

Increasing the CR from 2 to 5 yields almost 85% of the savings.

Strategies Summary:

- Increase cycles of recirculation
- Consider chemical free water treatment

3.1.2 Process water use reduction

3.1.2.1 Equipment Cooling

Single-pass systems use approximately 40 times more water than a cooling tower operating at 5 cycles of concentration to remove the same heat load. Convert single pass cooling system to closed loop systems.

3.1.2. 2 Flow Control,

Install flow control – turn off when not in use

3.1.2.3 Water-Treatment Equipment

Evaluate the laboratory's requirements for high-quality water, including the total volume and the rate at which it will be needed, so that the system can be properly designed and sized. Determine the real quality of water required in each application; use the minimum appropriate level of quality to guide the system design (FEMP 2004).

3.1.2.4 Laboratory dishwasher systems

Laboratory dishwasher systems use deionized or RO water to deliver water of different qualities in the rinse cycles. They are designed to remove chemical build-up on glassware, pipettes, and other types of equipment. Replacing very old and wasteful equipment is another strategy. Newer dishwashers use less water than older models. With newer models, the operator can also select the number of rinse cycles. Fewer cycles should be selected whenever possible, if that will not affect the quality of the product.

Impact Summary:

Implementing the strategies described in this section can significantly reduce water use. Using cooling tower instead of single path cooling by itself reduces water use by 90%. There will be additional power use but the total impact is more cost effective.

Strategies Summary:

- Convert single pass cooling system to closed loop systems
- Install flow control – turn off when not in use
- Re-evaluate the laboratory's requirements for high-quality water
- Improve dishwasher operation and water use

3.2 Labs Water Use Reduction Strategies in new building or major retrofit:

3.2.1 Reduced cooling tower make up water design

Cooling tower make up water use is an operational issue. By designing a system with higher cycles of recirculation (number of times the same water is returned to the tower), major saving in water use can be achieved. Evaluate water use in employing tested and credible chemical free treatment systems.

Impact Summary:

Increasing the CR from 2 to 5 yields almost 85% of the savings.

Strategies Summary:

- Increase cycles of recirculation
- Consider chemical free water treatment

3.2.2 Process water use reduction

3.2.2.1 Equipment Cooling

Single-pass systems use approximately 40 times more water than a cooling tower operating at 5 cycles of concentration to remove the same heat load. Install only closed loop cooling systems.

3.2.2. 2 Flow control valves

Design for installation of flow control valves to facilitate water flow management.

3.2.2.3 Rinsing Equipment

Install equipment used in rinsing to allow water in the last rinse of a cycle to be reused as the first rinse of the next cycle.

3.2.2.4 Water-Treatment Equipment

Establish the laboratory's requirements for high-quality water, including the total volume and the rate at which it will be needed, so that the system can be properly designed and sized. Determine the real quality of water required in each application; use the lowest appropriate level of quality to guide the system design (FEMP 2004).

3.2.2.5 Laboratory dishwasher systems

Laboratory dishwasher systems use deionized or RO water to deliver water of different qualities in the rinse cycles. They are designed to remove chemical build-up on glassware, pipettes, and other types of equipment. Newer dishwashers use less water than older models. With newer models, the operator can also select the number of rinse cycles. Fewer cycles should be selected whenever possible, if that will not affect the quality of the product.

Impact Summary:

Implementing the strategies described in this section can significantly reduce water use. Using cooling tower instead of single path cooling by itself reduces water use by 90%. There will be additional power use but the total impact is more cost effective.

Strategies Summary:

- Install only closed loop cooling system
- Install flow control valves
- Install equipment used in rinsing to allow water in the last rinse of a cycle to be reused as the first rinse of the next cycle
- Establish a sustainable laboratory's requirements for high-quality water
- Install water efficient dishwashers

3.2.3 Use of recycled or harvested water

3.2.3.1 Rainwater as a source

Rainwater is an excellent source of nonpotable water. It can be used in many of the applications in which condensate recovery water is used such as irrigation and flushing.

3.2.3.2 Treat process wastewater for down-cycled use in cooling towers, etc

3.2.3.3 Use grey water for irrigation and. Blow down from non chemically treated cooling tower is an example of grey water.

Impact Summary:

Cooling towers on average use 5 gallons/hour per ton of cooling load due to blow down and evaporation. All this would be saved if process waste water is used for makeup.

Strategies Summary:

- Collect rain water for use in irrigation and toilet flushing
- Process waste water is a good source for cooling towers make up water

3.3 Resources

Links to additional information

http://www.labs21century.gov/pdf/bp_water_508.pdf
http://hightech.lbl.gov/library.html

Standards and Programs

Lab21 EPC 2.2, Water Efficiency, http://www.labs21century.gov/index.htm
LEED 2009, Water Efficiency, Page 168, http://www.usgbc.org/

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